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Experiment Station Work—I.

Good vs. Poor Cows; Corn vs. Wheat; Much vs. Little Protein; Forage Crops for Pigs; Robertson Silage Mixture; Alfalfa; Proportion of Grain to Straw; Phosphates as Fertilizers; Harmful Effects of Muriate of Potash; Studies in Irrigation; Potato Scab; Barnyard Manure.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

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EXPERIMENT STATION WORK—I.*

GOOD VS. POOR COWS.

The ability to utilize food profitably and convert it into milk and butter is an individual characteristic, in which there is an immense variation among cows.

The difference in the profits from keeping good, medium, and poor cows has been strikingly illustrated by the experiment stations in their herd records and in various feeding experiments.

Thus, a bulletin of the Utah station, giving the record of 15 cows for one year, shows that the cost of the food eaten for each 100 pounds of milk produced varied with different cows from 29.48 to 52.07 cents. The cost of food per pound of butter ranged from 5.91 to 11.8 cents in the case of different cows, and with butter at 20 cents a pound the net profit from a cow for one year ranged all the way from $14.71 to $51.37. The cows were common natives and grades, selected with considerable care.

A recent experiment at the Pennsylvania station touches on this point. Nine cows, mostly Jerseys and grade Guernseys, were fed in an experiment lasting one hundred and fifty days. The difference between the profit from the best cow and the poorest cow during one hundred and fifty days was $33.10. The cost of the food was very nearly as much for the poorest as for the best cow, but the value of the product from the best cow was $64.32, while that from the poorest cow was only $28.06. This gave a net profit of $37.65 from the best cow, and only $4.55 from the poorest cow.

These figures emphasize the importance of keeping a record of the different cows of the herd, so as to know which of the cows are being kept at a good profit and which are only barely paying their keeping, and thus be able to weed out the unprofitable stock and improve the herd.

*This is the first number of a sub-series of brief popular bulletins based upon the work of the agricultural experiment stations. The object of these publications is to show some features of the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director Office of Experiment Stations.

CORN VS. WHEAT.

The interest recently manifested in the value of wheat for stock and the scarcity of information upon that point led the experiment stations to make various experiments to test its feeding value and to compare it with other grain foods commonly used for feeding. A review of the work on this subject, with statements as to the value of wheat, was given in Farmers' Bulletin 22. Recently the Pennsylvania station has reported experiments made to compare corn and wheat for steers, and the Maine station has given the results of a comparison of the same for cows.

In the experiments at the Pennsylvania station 20 high-grade Shorthorn steers were used. Chopped wheat was compared with corn-and-cob meal. In both cases corn stover and hay were fed in addition. The 20 steers were first fed a mixture of ground wheat and corn-and-cob meal. On this they required 8.41 pounds of digestible food per pound of gain. They were then divided into two lots, one lot getting corn-and-cob meal and the other lot ground wheat. It was found that the lot receiving corn-and-cob meal required 7.73 pounds of digestible food to make 1 pound of gain in weight and the lot receiving the ground wheat ate 8.67 pounds of digestible food per pound of gain. The conclusion is reached that "corn has a slightly higher value for feeding steers than wheat."

The Maine station compared wheat meal (ground wheat) with corn meal for cows giving milk. In addition to this, 18 pounds of timothy hay and 2 pounds of cotton-seed meal were fed to each cow daily. The indications from this experiment were that the wheat-meal ration was more efficient than the corn-meal ration, and maintained the cows in rather better order. As to which would prove the most economical feed will, of course, depend on the local prices.

EFFECT OF RATIONS RICHER AND POORER IN PROTEIN.

There has been much said and written about the amount of protein or nitrogenous materials which should be fed to farm animals in proportion to the other constituents of the food. This proportion has been called the "nutritive ratio" of the food. If a ration is rich in protein it is called a "narrow ration," because the proportion between the amounts of protein and of other constituents is comparatively close. In the same way a ration poor in protein is said to be a "wide ration."

The Maine station has conducted an experiment with steers to study the effect of so-called wide and narrow rations upon the rate of growth and the composition of the carcass. One lot was fed a ration containing linseed meal, cotton-seed meal, and wheat bran, having a nutritive ratio of about 1:5.2 (narrow ration). The other lot was fed a ration containing corn meal and wheat bran, having a nutritive ratio of 1:9.7

(wide ration). Both lots were fed hay and, during the winter, corn fodder and silage also.

At the end of fifteen months of feeding, the steers on the ration richer in protein (narrow ration) had gained 221 pounds more than those on the wide ration. The kind of growth caused by the two rations—that is, the proportion of water, protein, fat, etc., in the body of the steers—was not materially different. This was true whether the entire bodies, the dressed carcasses, or the edible portions of the carcasses were considered. In other words, the proportion of fat to lean in the meat was not materially changed by the kind of rations fed. The relative weights of the organs and parts of the body were practically the same with the steers of the same age fed on either ration.

The author believes that the superiority of the ration rich in protein over the ration poor in protein during the first year of growth is emphatically shown by the increased gain, and also by the smaller amount of digestible food required to produce 1 pound of growth. During fifteen months of feeding the digestible food eaten for each pound of growth which the steers made was 5.11 pounds for the lot receiving the narrow ration (rich in protein) and 6.16 for the lot receiving the wide ration. This superiority was also shown by the better general condition of the steers on the narrow ration.

The superiority of the richer ration over the other diminished as the steers increased in age. This is in conformity with the principles upon which feeding standards are based. These standards call for a diminished proportion of protein in the rations of growing animals as the animals approach maturity.

An experiment on the effect of wide and narrow rations for milch cows has been made at the Pennsylvania station. Nine Guernsey or grade Guernsey cows about sixty days from calving were used. Corn stover and chopped wheat were fed with different amounts of Buffalo gluten meal, cotton-seed meal, and linseed meal, so as to give rations with nutritive ratios ranging from 1:3.9 to 1:6.7. Seven of the nine cows used in the trial required less digestible food for a pound of butter in the periods when the rations richer in protein were fed. There was a small apparent increase in the efficiency of the food in the periods when the narrower rations were fed (i. e., rations rich in protein). After deducting the cost of the food there was also a somewhat larger net profit from feeding the rations richer in protein. The percentage of fat was better maintained and, in fact, increased slightly in the periods when the richer rations were fed.

In conclusion the author says:

> The impression that the increase in the proportion of protein in a ration, up to a certain limit, is accompanied by an increase in the efficiency of the food, and that the limit of this relative increase of protein is in practice determined by economical considerations, seems to be confirmed by the results of the experiment.

In the second experiment, also with steers, which was made in a similar manner, the lot on corn silage had 6 pounds of mixed grain per head per day and the lot on the Robertson mixture 2 pounds. The gain of the two lots during sixteen weeks was practically alike, amounting to nearly 1.6 pounds per day, but whereas the cost per pound of gain was 8.7 cents for the lot on corn silage, it was 7.71 cents for the lot on the Robertson mixture.

For eight weeks following this trial the lots were reversed, the one which had previously received corn silage receiving the Robertson silage mixture, and vice versa. During this time the lot on the Robertson mixture made an average gain of 82 pounds and the lot on corn silage 53 pounds per head. The cost per pound of gain was 7.83 cents for the lot on the Robertson mixture and 14.93 cents for the lot on ordinary silage. It is calculated that for the whole twenty-four weeks the cost of the gain on the Robertson mixture was over one-quarter less than on the ordinary silage.

The Vermont station compared the Robertson silage mixture with ordinary corn silage in feeding experiments with milch cows. "Considering the yield from the dry matter contained, the balance is strongly in favor of the Robertson mixture, more milk and butter being produced than from similar weights of dry matter in corn silage. The cows, if anything, gained in weight on the mixture. It seems that, in this test, at any rate, the claims made for the mixture are not without basis." A comparison of the Robertson mixture with cut beets and carrots in a short trial at the Vermont station did not bring out any material difference between these materials as fed.

In some experiments on this point made at the Maine station, black-eyed peas were used in place of the horse beans in the Robertson mixture. One-fourth acre of sunflowers and one-half acre of black-eyed peas were used to one acre of corn. All were run through the cutter and packed in the silo by the ordinary method, and the silage kept perfectly. When opened in February it was found to be in first-class condition. This silage was tested with five milch cows. It was very greedily eaten by stock. It was fed in place of one-half of the grain ration of corn meal, cotton-seed meal, and bran, 20 pounds of silage for 3 pounds of grain, with good results. All the cows increased in weight and shrank no more in milk than would be expected from the advance in time of lactation. An attempt to substitute the silage mixture entirely for the grain was not a success.

The silage with 76 per cent of water contained 2.9 per cent of protein, whereas the average of a large number of analyses of corn silage shows 1.7 per cent of protein.

ALFALFA.

Two experiment stations have recently issued bulletins of much importance on this subject. A bulletin from the Colorado station gives the result of very exhaustive studies on the growth of the alfalfa

plant, its changes in composition at different stages, its fertilizing value, the vitality of alfalfa seed, etc.

From the experience at the station and elsewhere, the author believes alfalfa to meet the requirements of a large variety of soils and climates, and regards it as an excellent forage crop of great adaptability.

"The most trying and fatal condition to this plant is a cold wet winter and poorly drained or water-logged soils. It has long been observed that stagnant water has a very injurious effect upon this plant, destroying its roots." The effect of stagnant water where alkali is present is said to be especially marked.

As showing the difference in composition between the stems and the leaves of alfalfa, analyses are given of the leaves at different stages of growth, from the time the plant begins blooming until after blooming. The air-dry stems contained about 6.35 per cent of protein and about 28 per cent of nitrogen free extract (carbohydrates), while the air-dried leaves, up to the time the plant ceased blooming, contained all the way from 22 to 25.5 per cent of protein and from 40 to 45 per cent of nitrogen-free extract. The leaves are also much richer in fat; but the stems contained 4 or 5 times as much crude fiber as the leaves.

The richness of the leaves has an important bearing on losses in making alfalfa into hay, as the leaves being brittle are readily broken off in handling and are, to some extent, left in the field. As to the different crops of alfalfa, of which there were three, the average percentages of protein did not differ very greatly, although the protein was somewhat higher in the first cutting. On this point the author says:

I would remind the feeder who prefers the second or even the third crop for certain feeding that the amount of protein present is not the only measure of good hay. Not only is the yield greater in the first cutting, but the quantity of protein is also greater, and the hay cut just at the beginning of bloom is richer in this constituent than that cut later. From the beginning of bloom to half bloom, the amount of protein seems to be nearly stationary and the crop is also probably at its maximum. * * * If the plant continues to store up organic matter after this period is passed, I am inclined to think that the losses by the dropping of leaves due to the maturing of the plant, and the action of the fungus common on the alfalfa, more than equals the gain. The crude fiber of the whole plant gradually increases as the plant matures. From the beginning of bloom to half bloom the increase is very rapid and the averages obtained for the hays of different cuttings are nearly equal.

Alfalfa hay is compared with clover hay, showing that 100 pounds of clover hay contains 47.5 pounds of digestible food, of which nearly 7 pounds is protein, while 100 pounds of alfalfa contains 54.5 pounds of digestible food with over 11 pounds of protein.

The losses in making alfalfa hay, referred to above, together with other considerations, led to some experiments in making alfalfa into silage. The ensiled alfalfa was preserved in good condition and cows ate it freely, even in early fall when they had access to green pasture. The alfalfa silage was nearly twice as rich in protein as ordinary corn silage.

The amount of fertilizing materials removed from the soil in a ton of alfalfa hay is given as 44 pounds of nitrogen, 8.27 pounds of phosphoric acid, and 50.95 pounds of potash. It also removes over 40 pounds of lime. On the above basis, a crop of three cuttings yielding 3.8 tons of alfalfa per acre, which is estimated by the author as an average crop, would remove from the soil 167 pounds of nitrogen, 31 pounds of phosphoric acid, and 194 pounds of potash. It is to be remembered in this connection that alfalfa belongs to that class of plants which are able to derive their nitrogen largely from the atmosphere, especially when they are required to do this by an inadequate supply of nitrogen in the soil.

Quite extensive studies were made on alfalfa seed to test the vitality of prime seed and different grades of screenings. The indications were that the vitality of prime seed was not materially affected by keeping it six years. "These tests and observations also strengthen the claim that in practice screenings produce as satisfactory results as prime seed." On the basis of the lowest vitality found for any screenings, it is calculated that 20 pounds of screenings per acre would be sufficient to give a stand which would produce a maximum crop. It is said to be a quite common practice among farmers to sell their prime alfalfa seed and use the screenings themselves. Some claim that no difference can be seen in the results, screenings producing just as good a stand of healthy plants as the first-class seed.

At the Utah station, where investigations on the growing and feeding of alfalfa have been in progress for a number of years, some studies have also been made in connection with feeding experiments mentioned below, on the composition of early, medium, and late cut alfalfa of the first and second crops. In each case the alfalfa cut just before blooming was richer in protein than that cut later, but neither the first nor second crop was as rich in protein as the third crop.

FEEDING ALFALFA.

A recent bulletin of the Utah station deals with the feeding value of alfalfa for steers. Experiments in this line have been in progress for three years, including comparisons of early, medium, and late cut alfalfa, and of the first, second, and third crops. A section of a field of alfalfa was cut just before blooming and this was designated as early cut; another section, cut about a week after blooming commenced, was designated as medium cut; and a third section, cut about one week after full bloom, was designated as late cut.

In some periods the alfalfa was fed without grain and in others bran and wheat were added. The results show that steers fed alfalfa, either with or without grain, made the most rapid gain on the early cut, and the least gain on the late cut. This was true for the early cutting of both the first and second crops. Pound for pound, the early cutting gave the best result; that is, less food was required per pound of gain when early-cut alfalfa was fed than on either medium or late cut. The early cutting also yielded the most hay, medium cutting

came second. The author estimates that fully one-third more beef can be produced on an acre with early cuttings than with either medium or late cuttings.

For the different crops of alfalfa the rate of gain and the food required per pound of gain both favored the third crop, the first crop being second in value: There was very little difference in composition between the first and second crops of alfalfa, but the third crop contained more protein and less fiber than the other crops, thus indicating its superior feeding quality. Pound for pound, good alfalfa proved to be equal to timothy hay, while in the rate of gain it proved better, and alfalfa was noticeably superior to clover hay. Adding straw to the ration of alfalfa and grain proved advantageous.

EFFECT OF FERTILIZERS ON THE PROPORTION OF GRAIN TO STRAW OR STOVER.

It is a matter of common observation that the proportion between the grain and straw is considerably influenced by the season, the soil upon which the crop is grown, and the variety. It is well known also that the kind and amount of fertilizer used exert an important influence upon this point.

In connection with a rotation experiment at the Pennsylvania station extending over twelve years, the effect of different fertilizers upon the relation of grain to straw or stover has been studied more or less incidentally.

In these experiments the following fertilizers have been used singly and in various combinations: Dried blood, dissolved boneblack, muriate of potash, nitrate of soda, sulphate of ammonia, barnyard manure, lime, ground limestone, plaster, and ground bone. The results, as recently summarized by the station, indicate that in the case of corn the average for 24 different fertilizers was 51.8 pounds of stover (stalks without ears) for each bushel of unshelled corn (70 pounds). The average proportion for the 7 complete fertilizers was 55.4 pounds of stover per bushel of corn, and of these barnyard manure gave the smallest proportion of stover to ears (47.6 pounds), and the complete fertilizer containing dried blood the largest (58.1 pounds). Complete commercial fertilizers materially increased the proportion of stover to ears as compared with barnyard manure.

In the case of oats, however, the largest relative yield of straw was from the barnyard-manure plats, which showed about 10 per cent more straw in proportion to the grain than the plats receiving complete commercial fertilizers. The average for the 24 different fertilizers was 45 pounds of straw per bushel of oats (32 pounds), and the average for 7 complete fertilizers was 42 pounds of straw, of which barnyard manure gave the largest proportion (46.2 pounds). Complete fertilizers containing sulphate of ammonia gave about 7 per cent more straw in proportion to grain than either nitrate of soda or dried blood.

With wheat the average proportion of straw for all the plats was 101 pounds per bushel of grain (60 pounds). Complete fertilizers increased the proportion of straw, and among them barnyard manure showed the least increase and sulphate of ammonia the greatest.

Except in the case of corn, increasing the amount of nitrogen per acre (24, 48, and 72 pounds) regularly increased the amount of straw to a bushel of grain. While these relations of fertilizers to the proportions of grain and straw may not hold good under all conditions, they are interesting as showing the way in which different fertilizers may affect the relation through a series of years, and may have a bearing in the selection of fertilizers.

COMPARATIVE FERTILIZING VALUE OF DIFFERENT PHOSPHATES.

The different phosphates used in fertilizers differ widely in availability, i. e., in the readiness with which they are taken up by plants, and different plants have been found to vary greatly in their capacity to assimilate the phosphoric acid of a given phosphate. The insoluble phosphates are much cheaper than the soluble forms. Phosphoric acid in soluble form costs in the market from 4 to 6 cents per pound (often more in mixed fertilizers), while that of the crude mineral phosphates is worth less than 2 cents per pound. If, therefore, it can be shown that certain plants can utilize some of the insoluble phosphates to good advantage the outlay for phosphates may be greatly reduced.

The Maine Experiment Station for a number of years has been conducting experiments in boxes filled with sand almost free from phosphoric acid to determine the ability of different kinds of plants to utilize the phosphoric acid of various commercial phosphates. Among the phosphates experimented with were dissolved Florida rock phosphate (containing total phosphoric acid 20.60 per cent, water-soluble 14.97 per cent), crude finely ground Florida rock phosphate (32.88 per cent of phosphoric acid, insoluble), and a mineral phosphate of iron and alumina from the island of Redonda (49.58 per cent of phosphoric acid, insoluble in water). The first of these, it will be seen, furnishes soluble phosphoric acid, the second and third insoluble. The plants grown were peas, clover, turnips, ruta-bagas, barley, corn, tomatoes, and potatoes. (See figs. 1, 2, and 3.)

As was to be expected, the soluble phosphoric acid proved most available in every case. It induced prompt early growth, and thus tended to hasten the maturity of the crop. Nevertheless the insoluble phosphates were used more or less freely by all of the plants, the finely ground Florida phosphate appearing to be more available than the Redonda phosphate. The different plants, however, showed great variation in their ability to use the insolublephosphates.

From almost the very earliest period of growth the two varieties of turnips appeared to feed nearly as freely upon the Florida rock as upon the dissolved Florida

rock, whereas the barley, corn, potatoes, and tomatoes derived but little if any benefit from the phosphates insoluble in water until during the more advanced stages of

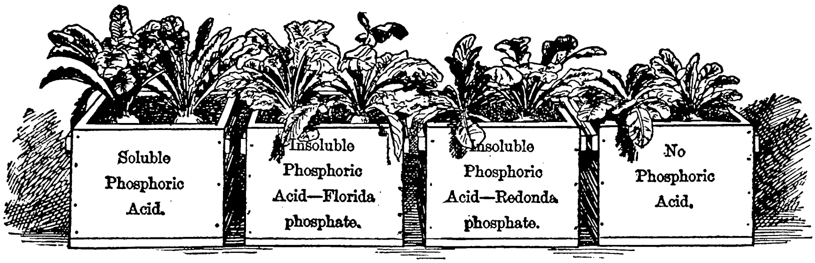

FIG. 1.—The effect of various commercial phosphates, as compared with no phosphoric acid on the growth of turnips.

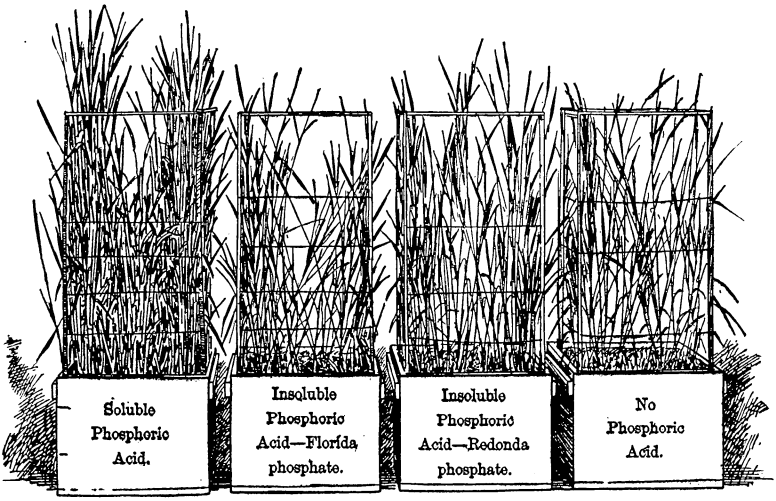

FIG. 2.—The effect of various commercial phosphates, as compared with no phosphoric acid, on the growth of barley.

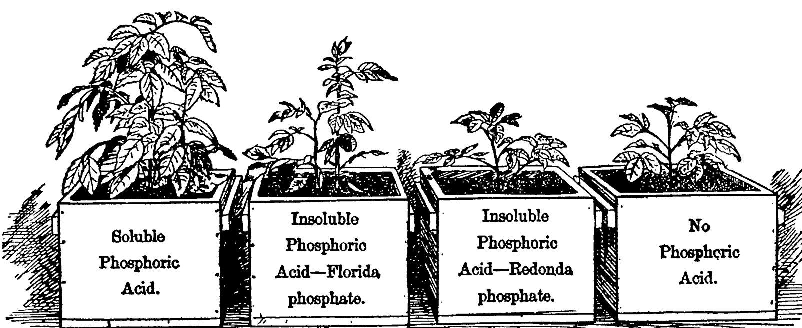

FIG. 3.—The effect of various commercial phosphates, as compared with no phosphoric acid, on the growth of potatoes.

growth, and even then the benefit was not nearly so marked as with the [turnips and ruta-bagas].

The leguminous plants, viz, peas and clover, appeared to occupy a position between

the [turnips and ruta-bagas and the barley and corn], showing a very material increase of early development due to the water-insoluble phosphates. * * *

The ability to appropriate water-insoluble phosphoric acid appeared with some species of plants to greatly increase as the plants developed.

While the turnips and ruta-bagas fed freely upon the crude Florida rock, even in the earlier stages of growth, it was observed that not until after some weeks did the clover, tomatoes, and in one case the corn, begin to make any perceptible use of the water-insoluble phosphates.

The figures showing the clover in two stages of growth illustrate the above statement very clearly. (See figs. 4 and 5.) This observed increase of feeding power as the plants matured, so that they fed upon the crude ground rock, especially the clover, suggests that the crude ground phosphates may be made a cheap and useful source of phosphoric acid in grass fields; and on the other hand the inability of sev-

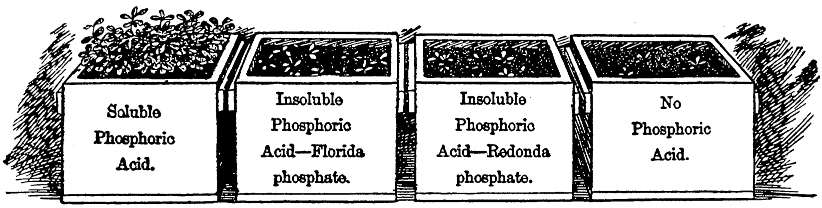

FIG. 4.—The effect of various commercial phosphates, as compared with no phosphoric acid, on the growth of immature clover.

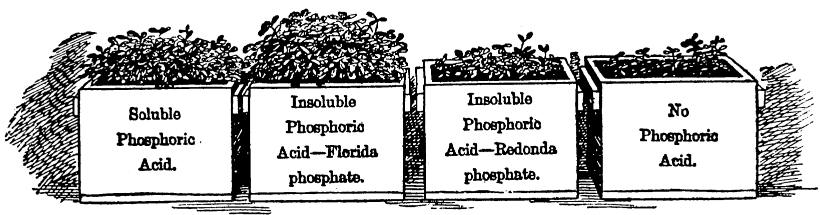

FIG. 5.—The effect of various commercial phosphates, as compared with no phosphoric acid, on the growth of mature clover.

eral species [barley, corn, potatoes, and tomatoes] to use the water-insoluble phosphates freely in the earlier periods of growth, emphasizes the wisdom of using chiefly water-soluble phosphoric acid upon hoed crops, especially where early maturity is essential.

These experiments suggest also that it may be profitable on certain crops grown on a large scale to combine the soluble and insoluble phosphates, applying a small amount of the former at time of planting to hasten the early growth of the crop, and a larger amount of the latter a few weeks later to supply the wants of the more advanced plants. In this way the outlay for phosphoric acid would be greatly reduced and probably the yield in no way decreased.

FERTILIZING VALUE OF GROUND BONE.

The value of ground bone as a source of phosphoric acid for plants has recently been the subject of very extensive and careful investigation by several of the most eminent German authorities on fertilizers, and the

results obtained and the conclusions reached demand the serious attention of American farmers, particularly as they are somewhat at variance with widely accepted views. The experiments were made under a great variety of conditions of soil, season, and crop, and extended over a number of years, and the different experimenters, working independently, arrived at practically the same conclusions, viz:

Undissolved ground bone considered simply as a source of phosphoric acid is no more valuable than the crude mineral phosphates. "It yields no better results than mineral phosphates, whether tried alone or with superphosphate, on loams or sandy soils, on soils rich or very poor in phosphoric acid, whether with grains or with turnips, mustard, or other cruciferous plants, either in the first or in the succeeding crops." Ground raw bone contains from 2.5 to 4.5 per cent of nitrogen, steamed bone from 1.5 to 2.5 per cent; and it is claimed that the superior value which has hitherto been accorded to bone meal is due to this nitrogen. In other words, if the nitrogen could be removed without affecting the chemical character of the phosphate of lime which the bone contains, this phosphate would be no more valuable as a fertilizer than an equal amount of crude mineral phosphate of lime, such as fine-ground South Carolina or Florida rock phosphate.

When, therefore, a soil needs phosphoric acid but does not need nitrogen it would seem to be of doubtful economy on the part of the farmer to apply phosphoric acid in the form of bone, when according to the above experiments equally effective phosphoric acid may be obtained in the form of mineral phosphates, which are much cheaper than bone. On the other hand, if the soil is likely to profit by applications of both nitrogen and phosphoric acid bone furnishes a valuable and economical source of these fertilizing constituents.

It must also be borne in mind that the phosphate in bone is intimately mixed with organic matter which rapidly undergoes decomposition in the soil, causing the bone to disintegrate, and thus probably assists in rendering the phosphoric acid of the bone assimilable.

THE HARMFUL EFFECTS ON SOILS OF THE CONTINUED USE OF MURIATE OF POTASH.

Muriate of potash is extensively used as a source of potash in fertilizers. It is a very concentrated fertilizer, each 100 pounds of it containing about 50 pounds of actual potash. The potash in this form is, as a rule, somewhat cheaper than in the form of sulphate of potash. If, therefore, it is as effective as the sulphate and does no injury to soil or crop it is advisable to use it in preference to sulphate. It has been found, however, that although the muriate of potash is, as a rule, a very valuable fertilizer the chlorin with which the potash is combined in it may injurously affect the quality of certain crops, such as potatoes, tobacco, etc.; and recently Professor Goessmann, of the Massachusetts station, has observed that if the muriate is used without proper

precautions on soils with a limited supply of lime the full benefit of the potash which it supplies may not be obtained because the lime of the soil is converted into a soluble form which is either washed out in the drainage or accumulates in the upper soil and poisons the plants. He observed that oats, rye, and soja beans grown on soil which had received applications of muriate of potash for a number of years in succession continued to decrease in yield and were unhealthy in appearance, and it was suspected that this condition was due to the action of the muriate of potash on the lime of the soil.

When common salt (sodium chlorid) and muriate of potash (potassium chlorid), which are readily soluble, are brought in contact under favorable conditions with the insoluble carbonate of lime, the form in which lime chiefly occurs in the soil, a chemical change takes place by which the lime is converted into a form (chlorid) soluble in water and poisonous to plants. An examination of the drainage water of the soil showed the presence of considerable amounts of the soluble lime compound (chlorid) in the soil fertilized with muriate of potash (much greater than where sulphate had been applied), and thus confirmed the opinion that some such chemical change as the above had actually taken place in the soil. The valuable potash had passed into more insoluble forms and was thus protected from leaching—a very desirable result—but this was accomplished at the expense of the lime. If lime is abundant in the soil and drainage good no immediate harm is likely to result from such a change in a favorable season, but if, as was the case in the soil experimented with here, the supply of lime is limited, serious results may follow the continued use of muriate of potash unaccompanied by applications of lime. The conclusion that the unhealthy appearance and decrease in yield of the crops in these experiments were due to loss of lime from the soil was confirmed by the fact that when 500 to 600 pounds per acre of lime was "applied broadcast early in the spring, and subsequently plowed under before preparing the soil for manuring and seeding, the succeeding crops of oats looked healthy from the beginning to the end of the season."

On account of the poisonous properties of the lime compounds formed, muriate of potash is a safer fertilizer on a deep soil with open subsoil than upon a shallow soil with a compact clayish subsoil, because in the former the injurious lime compounds formed pass readily out of the reach of plants while in the latter they tend, as already suggested, to accumulate in the surface soil where they may work great injury to the plant.

These objections to muriate of potash do not apply to the sulphate. Therefore, if the two forms are equally available it would be advisable in case of soils containing a limited supply of lime to use the sulphate instead of the muriate. If the muriate of potash is used liberally it should be accompanied by periodical applications of lime.

RECENT PROGRESS IN THE STUDY OF IRRIGATION.

According to Newell, "the area irrigated within the arid and subhumid regions in the western part of the United States during the census year ending May 31, 1890, aggregated 3,631,381 acres or 5,674.03 square miles, approximately 0.4 per cent of the total area west of the one hundredth meridian." The arid region where irrigation is an absolute necessity for successful agriculture embraces in part or in whole the following States and Territories: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. The subhumid region where as a rule insufficient rain falls for full crops includes parts of North Dakota, South Dakota, Nebraska, Kansas, and Texas. A large proportion of the irrigable area in these vast regions still remains to be irrigated.

The necessity for irrigation, moreover, is beginning to be felt in the so-called humid regions east of the one hundredth meridian, and within comparatively recent years widespread interest has been manifested in the subject of irrigation in this region. In recent years widespread drought, especially at critical periods in the life of certain crops, has drawn the attention of Eastern farmers and horticulturists to this subject. Truck farmers and fruit growers, especially in regions accessible to good markets, are beginning to appreciate the importance of irrigation.

King has found that even in favorable seasons in Wisconsin, which is in the so-called humid region, the rainfall does not supply sufficient moisture to produce maximum crops. During the season of 1896, in which the rainfall was normal in that State, a variety of crops was irrigated with profit, notwithstanding the fact that the irrigation plant employed was not used to its full capacity and thus the cost of irrigating was higher than it need be. The profit from irrigation was on corn, $2.16 per acre; potatoes, $11.70; clover hay (irrigating second crop only), $1.72; cabbages, planted thin, $2.43, planted thick, $29. "The great lesson," says King, "to be learned from these results is that we must have an abundance of water in order that our crops may avail themselves of the plant food stored in our soils, not that water is everything, but the fertility of the soil counts for naught without it."

The above statements give us some idea of the great and increasing importance of irrigation to the American farmer. Recent investigations on this important subject have given some results of considerable practical value, and it is the purpose of this article to briefly summarize these results.

The greatest profit is derived from irrigation where intensive farming is practiced. In fact, the practice of irrigation naturally leads to intensive farming. In such farming the aim should be to economize all the elements of fertility, to utilize water, fertilizer, labor, etc., to the best possible advantage. If fertilizers are used they will give the best returns if kept in the upper layers of the soil, where they can be fully

utilized by the plant. If irrigation is practiced also, the amount of water applied should not be excessive, otherwise the fertilizing materials are either washed into the lower layers of the soil where they can not be utilized by the plant or are entirely removed in the drainage.

Edmond Gain, a French authority, has shown that the water requirements of plants differ widely at different stages of growth. His observations show that it would be very injurious to the plant, even if it were possible, to maintain a uniform state of moisture in the soil. He observed, for instance, that for the ordinary farm crops the optimum, or most favorable amounts, of moisture in the soil at different stages of growth, were about as follows: At the time of planting the soil should have about 25 per cent of the total amount of water which it is capable of holding, then it should fall to 15 per cent and remain at this point until the first leaves are formed, when it should be raised quickly to nearly 40 per cent. It should be allowed to fall rapidly to about 25 per cent and remain at this point until shortly before flowering, when it may be

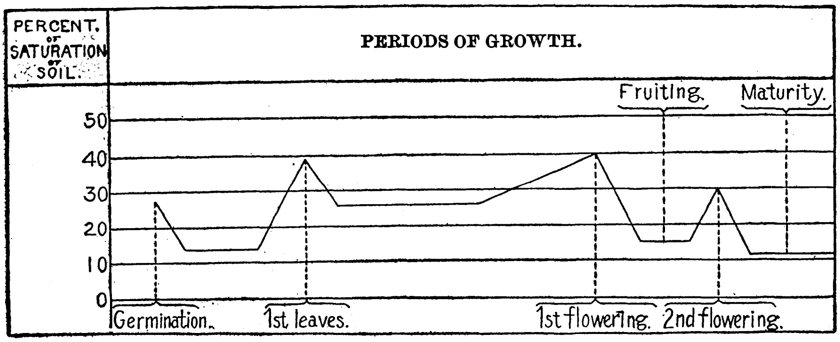

FIG. 6.—Water requirements of plants at different stages of growth.

raised gradually to 40 per cent and then allowed to fall rapidly to 12 or 15 per cent, where it remains during fruiting and maturity (see fig. 6). Briefly, then, the soil should be only moderately moist at time of planting and comparatively dry thereafter until the first leaves are formed, when it should be thoroughly irrigated. It should then be allowed to become comparatively dry and remain so until the flowering stage, when it should have its most liberal irrigation. After this it should be allowed to become dry during fruiting and maturity. Of course this represents ideal conditions which can not be completely secured in practice, but it suggests how irrigation water may be greatly economized at the same time that the most favorable conditions of growth are secured for the crop.

This alternation of dry and wet periods has another important point in its favor on ordinary soils. Hilgard has shown that it furnishes the ideal conditions under which the soluble constituents of the soil rise to the surface. The evaporating water leaves the matter which it holds in solution at the place where it evaporates, i. e., at the surface of the

soil. It thus keeps the valuable fertilizing constituents of the soil within easy reach of the crop. On "alkali" soils, however, under the above conditions the corrosive poisonous alkaline salts would accumulate at the surface to the destruction or great injury of the crop.

Methods of applying irrigation water, especially surface irrigation and subirrigation, have been tested by a number of the experiment stations in both arid and humid regions. The results have generally been unfavorable to subirrigation. The laying of the underground pipes necessary in this system is of course expensive, and, moreover, it is difficult, if not impossible, in subirrigation to obtain a uniform distribution of the water throughout the soil on account of the fact that while water moves up and down in the soil with comparative rapidity it moves from side to side very slowly. The irrigation pipes being out of sight it is impossible to note the movement of the water with accuracy. The soil immediately surrounding the pipes may become excessively wet, while a large proportion of the soil between the pipes is insufficiently irrigated. Moreover, a considerable amount of the water may pass down into the lower layers of the soil without being of the slightest benefit to the crop. King found that a given amount of water was much more effective in increasing the yield of corn when applied by surface irrigation than when applied by subirrigation.

Rane, of the New Hampshire Experiment Station, in experiments with celery on clay loam soil "with water applied both through ditches for surface irrigation and through tiles below the reach of the plow for subirrigation" found that "the latter system required much more water than the former for the same results."

[A method of tile irrigation which he has found to possess decided advantages over ordinary subirrigation] was to place common porous 2½-inch drain tiles in a continuous row, end to end, on the surface of the soil, vegetables being planted on either or both sides of the line. The tiles were 1 foot long, and by pouring in the water at one end of the line it was distributed at the joints throughout the length desired when the opposite end was stopped up. Take celery as an example crop for irrigation on uplands. We plant the celery as above stated, and while it is young we have simple surface irrigation; but as the crop grows we bank it up, and finally have the tiles covered, and thus have subirrigation. The tiles are cheap and last indefinitely. When the celery is harvested, the tiles are dug out also and piled up or used for subirrigation in the greenhouse beds. Potatoes and various other crops can be grown in the same way. The celery watered this year grew well and did not rust. Besides this, we were able to water twenty times as much space in the same time as in the ordinary way with ditches. Besides saving time, this plan delivers water where it is most needed, and we have reason to believe is fully as economical with water as with time.

Experiments during two seasons have shown that with this method "the plants did fully as well as in the other systems and with less water."

Where irrigating is to be done on a large scale, it seems to be the consensus of opinion that surface irrigation by means of furrows is undoubtedly the most practical method. In greenhouses and gardens

subirrigation by means of tiles may often be found advisable. Furthermore, many soils need drainage and require the laying of tile. On such soil it may be possible to combine drainage and subirrigation economically, and the Wisconsin Experiment Station is at present studying this subject.

A question of the greatest importance in regions of deficient rainfall or where irrigation is practiced is the storage capacity of the soil for water. When the soil is thoroughly loosened up, the amount of water which it will hold is greatly increased, and the rise of water to the surface and evaporation are checked. Experiments at the Wisconsin and Nebraska Experiment stations have shown the beneficial effects in these respects of subsoiling. On this point the Nebraska station makes the following suggestions:

Subsoil plowing, although a means of conserving moisture, does not produce it, and is, therefore, not a substitute for irrigation where the rainfall is too small to produce crops.

Where there is a hard, dry subsoil, subsoil plowing is to be recommended.

Where the subsoil is loose, gravelly, or sandy, subsoiling is probably unnecessary, or may even be injurious.

Do not subsoil when the soil is very wet, either above or beneath, as there is great danger of puddling the soil, thus leaving it in worse condition than before. This is one of the reasons why it is better to subsoil in the fall than in the spring.

If the ground be subsoiled in the fall, the winter and spring rains have ample opportunity to soak in, that being the season of greatest rainfall and least evaporation.

Subsoiling in the spring may be a positive detriment if the subsoil be extremely dry, as in that case the rain water is partially removed from the young plant by the absorption of the bottom soil. If the spring rains were heavy, this would not be a disadvantage.

It is probable that the increased yields on subsoiled lands are mainly, if not entirely, due to the increased amount of water which such land is able to store up for the use of the crop. Subsoil plowing may thus be made the means of greatly extending the area over which crops may be successfully grown without irrigation, and when practiced in connection with irrigation may result in a great saving of irrigation water. As indicated above, however, before deciding upon the advisability of subsoiling it is necessary to ascertain, among other things, the nature and condition of the soil and subsoil.

POTATO SCAB.

The disease of potatoes which results in the formation of brownish scab-like patches on the surface of the tubers is so well known as not to require any detailed description. It is generally attributed to a microscopic organism to which the name *Oöspora scabies* has been given, although other agencies may, to some extent, produce similar effects.

Many of the experiment stations have studied this disease in order to ascertain the cause and remedy. The Connecticut State, Indiana, and North Dakota stations were the pioneers in this work and the

investigators at these stations discovered both the cause and some of the means for its prevention.

It was found that soaking the seed tubers before they were planted in a solution of corrosive sublimate would greatly decrease, if not entirely prevent, the appearance of scab on crops grown from such seed. The method of treatment recommended is to soak the thoroughly washed tubers for one and one-half hours in a solution of $2\frac{1}{4}$ ounces of corrosive sublimate in 15 gallons of water. It is best to dissolve the corrosive sublimate in 2 gallons of hot water and then dilute it to 15 gallons. As this mixture is very poisonous all the treated tubers should be planted and the remaining solution disposed of so that stock may not be injured by it. Metallic vessels are corroded by it, and one of the best as well as the most convenient vessels for use would be a large tub or a barrel.

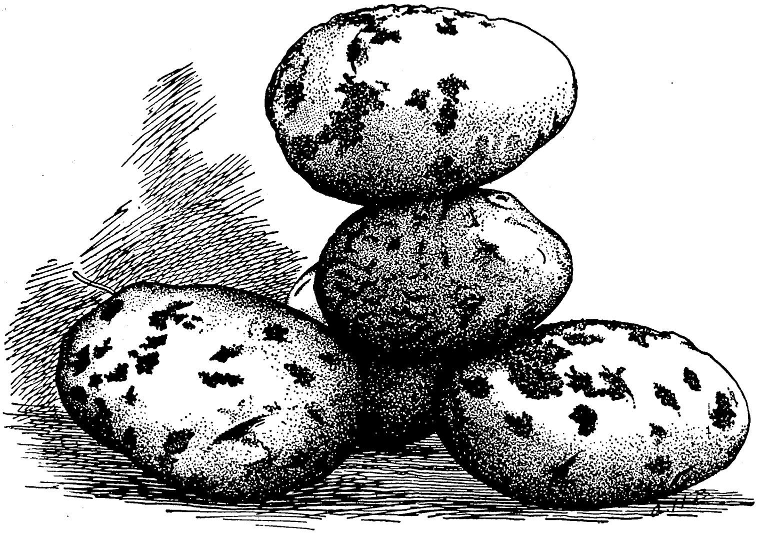

FIG. 7.—The scabby potatoes used as seed in the test.

After washing the tubers they may be placed in a bag of some coarse material (a coffee sack is good) and placed in the solution for the required time, after which they are dried, cut, and planted.

Experiments at the Michigan station showed that the entire cost of treatment need not exceed 2 cents per bushel. If treated in this way, a clean product may be obtained when the potatoes are planted in soil which is not already infested with scab. The effect of the treatment may be seen in the accompanying figures (figs. 7, 8, and 9), taken from the Annual Report of the Michigan Station for 1894, page 58. The scabby seed tubers are shown and with them the potatoes grown from this seed, treated and untreated. In extensive trials it was found that where treated seed tubers were used the crop contained only 6.8 per cent of slightly scabbed potatoes, as compared with 60.1 per cent of scabby potatoes where the seed was not treated. It was also found that longer

soaking tended to reduce the scab, but also reduced the yield. At the Indiana station the result of treating Beauty of Hebron potatoes shows for the treated lots 8.25 per cent of scab, as compared with 78 per cent for the untreated lots.

Recent investigations at the Indiana station indicate that soaking the seed tubers in a solution of formalin or formic aldehyde, 8 ounces in 15 gallons of water, will prove efficient in reducing the disease. This solution is said to have all the advantages of corrosive sublimate, without being poisonous, and if further experimentation demonstrates this to be true, it can be recommended with greater confidence than the other mixture.

An important factor to be considered in combating potato scab is the fact that the fungus is able to live in the soil for a considerable number of years, the exact time is not yet known. On this account potatoes

FIG. 8.—The crop resulting from treated seed.

should not succeed themselves in soil where a scabby product has been grown. Nor should beets be grown in such soil, for they, too, are subject to the disease, as shown by the accompanying figure (fig. 10) taken from a bulletin of the North Dakota station.

Experiments conducted in Rhode Island and North Dakota seem to indicate that acid soils restrain the development of the scab fungus and that the addition of lime, ashes, barnyard manure, or other alkaline fertilizers to an acid soil tends to increase the development of scab in about the same proportion that the acidity of the soil is decreased.

At the New Jersey and Delaware stations experiments have been carried on to test the effect of sulphur as a soil treatment for the prevention of scab. In New Jersey the cut tubers were rolled in sulphur, or sulphur was placed in the rows with them, and the amount of scab

appears to have been greatly reduced. Potatoes planted in ground which had received 300 pounds of sulphur and the same amount of kainit per acre the previous year were almost free from scab. This is claimed to show that the fungus was largely destroyed the first year or the fungicidal action is maintained for at least two years. In Delaware,

FIG. 9.—The crop resulting from untreated seed.

where the tubers were rolled in sulphur before planting, the results obtained indicate that such treatment will diminish the amount of scab in the crop where grown upon land presumably free from the fungus. Numerous other fungicides have been tested at different stations with varying results.

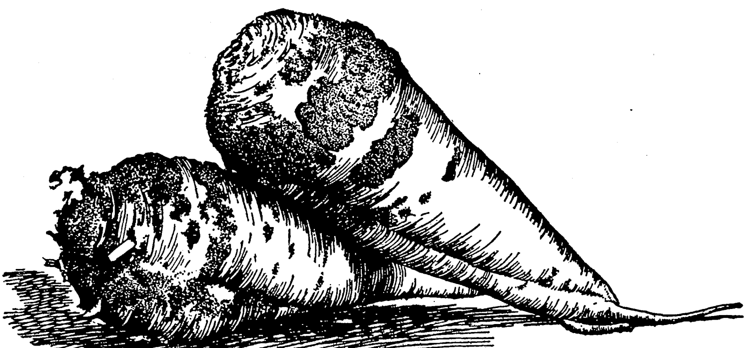

FIG. 10.—"Deep scab" of potatoes on beets.

At the South Dakota station eau celeste and Bordeaux mixture were found to greatly reduce the growth of scab, but they also reduced the yield. Dipping the seed tubers in solutions was found to be a more efficient method of treatment than spraying the cut potatoes in the open furrow. It is also claimed as a result of their experiments that

the thick-skinned, dark-colored varieties are less liable to scab than those not so protected. Further investigations along the line of resistant varieties would seem desirable.

BARNYARD MANURE.

The true fertilizing value of barnyard manure and the best and most economical methods of managing it have claimed much attention recently from a number of the foremost agricultural scientists of the world, and the conclusions they have reached are of great practical importance, for although the use of such manures is almost as old as agriculture itself, there are many questions related to their management and use which have never been clearly understood. It is well known that barnyard manure, if neglected, rapidly loses the greater part of its fertilizing value and becomes practically worthless, except to improve the mechanical and physical properties of the soil. It is also well understood by practical men that it is not economical to follow many of the elaborate methods of preservation which have been suggested. To be economical, the method of management must be simple and involve as little labor and expense as possible. The recent studies of scientific men on farm manures have been very largely directed to the very desirable practical end of simplifying methods of management and preservation.

Since the direct fertilizing value of manure depends so largely upon the nitrogen which it contains, the more important of these investigations have taken into consideration mainly the availability, changes, and causes and prevention of loss of this substance. It has been shown that there is a wide difference between the fertilizing value of the nitrogen of the solid and liquid parts of the manure. The effectiveness of the former has been found in experiments to be only 10 per cent of that of nitrate of soda, while the latter was over 90 per cent, being very nearly equal to that of sulphate of ammonia. The nitrogen of the solid excrement becomes available very slowly in the soil or in the heap, while that of the urine is in a soluble form, rapidly converted into ammonia which may escape into the air. Experiments are recorded which indicate that the effectiveness of the nitrogen of the solid excrement is not materially increased by mixing it with the liquid part, the nitrogen of such a mixture being decidedly less available than that of either nitrate of soda, sulphate of ammonia, or green manures. The conversion of the nitrogen of the urine into ammonia, moreover, is apparently hastened by the admixture of solid excrement and straw.

The changes which manure undergoes, which it brings about in the soil, and which so largely determine its fertilizing value, are mainly the work of microorganisms, beings which, like the coral-reef builders, are insignificant individually, but which multiply with almost inconceivable rapidity, and are thus able to accomplish startling results.

These microorganisms are on hand to begin their work as soon as the manure is voided; in fact, it is claimed that many of them come from the stomach of the animal along with the manure. At any rate, the air and the litter of the stable swarm with them, and the odor of ammonia which pervades the air very soon after the excrement is voided is evidence that they commence their work promptly.

These organisms are of various kinds. Some require air (or oxygen) in order to grow; others flourish only in the absence of oxygen. Most of them injuriously affect the quality of the manure, but some may be made beneficial. The management of manure becomes thus largely a question of controlling these minute, microscopic beings, which in practice can be recognized only by their work.

The most effective means of checking the action of those organisms which require oxygen for their growth is, of course, to exclude the air. Experiments are recorded in which it was found that they were capable of completely converting the nitrogen of urine into ammonia, which escaped in the air, in twenty-four hours when air was freely admitted, but that the escape of ammonia was almost entirely prevented by excluding the air, although the nitrogen was still largely converted into ammonia. The same changes, of course, occur in the solid excrement, but much more slowly. In one experiment mixtures of dung and litter which were exposed to the action of the air were found to lose as high as 17 per cent of the nitrogen which they contained in about seven months. In other experiments in which a current of air was drawn through the manure the loss was over 40 per cent.

It is due to the beneficial effect of excluding the air that deep-stall manure has been found so much more effective than that which has been stored in ordinary heaps. Maercker, an eminent German investigator, has recently found in experiments with oats that the nitrogen of deep-stall sheep manure compared favorably with that of sulphate of ammonia and nitrate of soda, while ordinary barnyard manure under the same conditions was either without effect or lowered the yield.

The unsatisfactory results with the latter were accounted for not only by the fact that the manure had probably lost a large part of its fertilizing value by the previous treatment to which it had been subjected, but also by the fact that the manure as well as the litter (straw, etc.) mixed with it contained peculiar microorganisms, known as denitrifying organisms, which are capable of converting available nitrogen into forms which are of little or no use to the plant when the manure is applied to the soil.[1] It should be stated, however, that in these experiments the manure was applied in much larger amounts than is usual in practice and the denitrifying organisms were thus distributed in the soil in sufficient amount to work injury. Other experiments indicate

[1] These organisms are especially abundant in horse manure and in straw.

that when manure is applied in the usual amounts this is not likely to occur; in fact, the proportion of nitrates in the soil may be increased rather than decreased under such circumstances.

Still we have here a possible danger which should be guarded against in the management of manure. Careful attention to the construction of the manure heap so that air will be as completely excluded as possible, keeping the heap moist, and avoiding alternate wetting and drying have been suggested as means of preventing loss of valuable fertilizing constituents and of promoting a decomposition which will largely reduce the power of the manure to convert available nitrogen into less valuable or useless forms (denitrifying power) in the soil. Here we have an explanation of the effectiveness of well-rotted manure; not only is the availability of its own nitrogen increased, but its power to injuriously affect available nitrogen from other sources is reduced.

Authorities agree that attention to the construction and management of the manure heap is much more important than the use of preservatives, with which the results have been contradictory. Kainit has been found to be effective in checking the formation of ammonia, and superphosphate in preventing its escape. The use of these is to be recommended where they can be cheaply obtained, because, in addition to preserving the manure, they add to it constituents (potash and phosphoric acid) in which it is somewhat deficient. Caustic lime has been found effective in destroying the denitrifying power of manure, above referred to, but there are certain serious objections to its use. It is well known that it has a tendency to drive off ammonia from organic matter such as manure. However, if the lime is applied to the fresh manure, the danger of loss from the escape of ammonia has been found to be very small. It is only after fermentation has commenced in the manure that the danger of loss on application of lime becomes serious. It has been suggested that it might be safe and economical to mix caustic lime or marl with the manure to destroy its denitrifying power and to cover the heap with earth to prevent the escape of ammonia. A second objection to lime is that it tends to convert the available nitrogen of manure into insoluble and less available forms, but this tendency is, in a measure, compensated for by the fact that, in addition to destroying the denitrifying organism, as already explained, the lime promotes nitrification, or the formation of nitrates, when the manure is applied to the soil. Lime should not be used in connection with superphosphate, because it renders the phosphoric acid which the latter contains insoluble and destroys the effectiveness of the superphosphate as a preservative.

Bisulphid of carbon almost entirely destroys the denitrifying organism, but its use in practice is not recommended because of its expensiveness. Sulphuric acid has proved very effective, not only preserving the fertilizing constituents but increasing the availability of the nitrogen, but its general use can hardly be recommended.

One point which has been clearly brought out by recent investigation is that the addition of straw may very decidedly reduce the fertilizing value of manure, the injurious effect being greater the larger the amount of straw used. This is explained by the fact stated above that straw contains organisms which convert the available nitrogen in manures and in the soil into forms which the plant can not utilize. The excessive use of straw as litter under animals should therefore be carefully avoided if the most effective manure is desired.

one part of protein for every five parts of the other digestible materials, the nutritive ratio is 1:5.

FEEDING STANDARDS are statements of the approximate amounts of digestible protein, fat, carbohydrates, etc., adapted to animals under different conditions.

NARROW RATION is one in which the ratio of protein to other constituents is narrow, i. e., one comparatively rich in protein.

WIDE RATION is one in which the ratio of protein to other constituents is wide, i. e., one comparatively poor in protein.

MISCELLANEOUS TERMS.

MICROORGANISM, OR MICROSCOPIC ORGANISM, is a plant or animal too small to be seen without the aid of a compound microscope.

NITRIFICATION is the process by which the highly available nitrates in fertilizers, soils, etc., are formed from the less active nitrogen of organic matter, ammonia, salt, etc. It is due to the action of minute microscopic organisms.

DENITRIFICATION is the process, due to microorganisms, by which the readily available nitrates are converted into less valuable forms of nitrogen.

FUNGUS is a low form of plant life destitute of green coloring matter. Mold is an example.

FUNGICIDE is a substance used to destroy fungi or prevent their growth.

BORDEAUX MIXTURE is a mixture of copper sulphate, freshly slaked lime, and water. It is used as a fungicide and also to prevent attacks of some insects.

CORROSIVE SUBLIMATE is a very poisonous compound of mercury and chlorin, used as a fungicide.

EAU CELESTE is a solution of copper sulphate in water to which ammonia is added, and it is used as a fungicide.

FORMALIN is a 40 per cent solution of formic aldehyde, used as a disinfectant, preservative, etc.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
No. 18. Forage Plants for the South. Pp. 30.
No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
No. 21. Barnyard Manure. Pp. 32.
No. 22. Feeding Farm Animals. Pp. 32.
No. 23. Foods: Nutritive Value and Cost. Pp. 32.
No. 24. Hog Cholera and Swine Plague. Pp. 16.
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No. 62. Marketing Farm Produce. Pp. 28.
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No. 66. Meadows and Pastures. Pp. 24.
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No. 68. The Black Rot of the Cabbage. Pp. 22.
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No. 78. Experiment Station Work—V. Pp. 32.
No. 79. Experiment Station Work—VI. Pp. 28.
No. 80. The Peach Twig-borer—an Important Enemy of Stone Fruits. Pp. 16.
No. 81. Corn Culture in the South. Pp. 24.
No. 82. The Culture of Tobacco. Pp. 23.
No. 83. Tobacco Soils. Pp. 23.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

COMPLETE FERTILIZER is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

NITROGEN exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrate. It is the most expensive fertilizing ingredient.

ORGANIC NITROGEN is nitrogen in combination with other elements either as vegetable or animal matter. The more valuable sources are dried blood, dried meat, tankage, dried fish, and cotton-seed meal.

AMMONIA is a compound of nitrogen more readily available to plants than organic nitrogen. The most common form is sulphate of ammonia, or ammonium sulphate. It is one of the first products that results from the decay of vegetable or animal substances.

NITRATES are the most readily available forms of nitrogen. The most common forms are nitrate of soda and nitrate of potash (saltpeter).

PHOSPHORIC ACID, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

SOLUBLE PHOSPHORIC ACID is that form which is soluble in water and readily taken up by plants.

REVERTED PHOSPHORIC ACID is that form which is insoluble in water but still readily used by plants.

INSOLUBLE PHOSPHORIC ACID is that form which is soluble only in strong acids and consequently very slowly used by plants.

AVAILABLE PHOSPHORIC ACID is the soluble and reverted taken together.

SUPERPHOSPHATE.—In natural or untreated phosphates the phosphoric acid is insoluble in water and not readily available to plants. Superphosphate is prepared from these by grinding and treating with sulphuric acid, which makes the phosphoric acid more available to plants. Superphosphates are sometimes called acid phosphates.

POTASH, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly if not quite equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources

of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of potash, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FEEDING STUFFS.

WATER is contained in all feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain, to 80 pounds in silage and 90 pounds in some roots.

DRY MATTER is the portion remaining after removing or excluding the water.

ASH is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the manure.

ORGANIC MATTER is the dry matter less the ash.

PROTEIN (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

ALBUMINOIDS is the name given to one of the most important groups of substances classed together under the general term protein. The albumen of eggs is a type of the albuminoids.

CARBOHYDRATES.—The nitrogen-free extract and fiber are usually classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy.

FIBER, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

CELLULOSE is the chief constituent of crude fiber.

NITROGEN-FREE EXTRACT includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

FAT, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

ETHER EXTRACT is the same as the fat or crude fat of feeding stuffs.

DIGESTIBLE MATTER is that portion of the food eaten which is actually digested. The rest is excreted and is of no aid in nutrition.

NUTRITIVE RATIO is the ratio of the digestible protein (taken as 1) to the other digestible materials of the food. Thus, if a ration contains

one part of protein for every five parts of the other digestible materials, the nutritive ratio is 1:5.

FEEDING STANDARDS are statements of the approximate amounts of digestible protein, fat, carbohydrates, etc., adapted to animals under different conditions.

NARROW RATION is one in which the ratio of protein to other constituents is narrow, i. e., one comparatively rich in protein.

WIDE RATION is one in which the ratio of protein to other constituents is wide, i. e., one comparatively poor in protein.

MISCELLANEOUS TERMS.

MICROORGANISM, OR MICROSCOPIC ORGANISM, is a plant or animal too small to be seen without the aid of a compound microscope.

NITRIFICATION is the process by which the highly available nitrates in fertilizers, soils, etc., are formed from the less active nitrogen of organic matter, ammonia, salt, etc. It is due to the action of minute microscopic organisms.

DENITRIFICATION is the process, due to microorganisms, by which the readily available nitrates are converted into less valuable forms of nitrogen.

FUNGUS is a low form of plant life destitute of green coloring matter. Mold is an example.

FUNGICIDE is a substance used to destroy fungi or prevent their growth.

BORDEAUX MIXTURE is a mixture of copper sulphate, freshly slaked lime, and water. It is used as a fungicide and also to prevent attacks of some insects.

CORROSIVE SUBLIMATE is a very poisonous compound of mercury and chlorin, used as a fungicide.

EAU CELESTE is a solution of copper sulphate in water to which ammonia is added, and it is used as a fungicide.

FORMALIN is a 40 per cent solution of formic aldehyde, used as a disinfectant, preservative, etc.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

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No. 18. Forage Plants for the South. Pp. 30.
No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
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